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By: J. Michael Neary - August 1, 2008
J. Michael Neary Date: August 1, 2008

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Gerald J. Julien	)	
		)	Group A.U. 3618
Serial No.:	10/505,356	)	
		)	Examiner: John Daniel Walters
Filing Date:	August 19, 2004	)	
Title:	Nitinol Ice Blades	)	

Transmittal Letter

August 1, 2008

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant submits herewith a report on the performance of Nitinol ice skate blades prepared by Dr. Alain S. Comtois of the Department of Kinanthropology at the University of Quebec in Montreal, and Francois Whittom and Olivier Desmeules of Whittom and Associiates Sports-Performance-Technologies. This report was commissioned by Triumph Sports, licensee of this application.

This report provides additional objective evidence of patentability of the claims in this application. It proves the superiority of Nitinol skate blades over regular steel blades in terms of speed and maneuverability on the ice. These characteristics were not recognized by experts in the art before Applicant made his invention, and indeed were not recognized by experts in the art even after Applicant's licensee provided test blades to the experts for testing. The experts were so certain of their

"knowledge" about the characteristics of a skate blade that they believed that the Nitinol skate blade, which apparently lacked these "essential" characteristics, would be inferior, and evidence to the contrary could not convince them otherwise. This actual evidence of what experts in the art thought about the invention, even after it was explained to them and demonstrated with actual test samples, is overwhelming evidence of the patentability of the invention. This situation is thoroughly detailed in the Declaration of Susan Bucanan, of record in this application.

There is nothing in the published PCT application of Julien that would make it obvious to use Nitinol for skate blades. One must ask, if experts in the skating art rejected the invention even after having a thorough explanation of their use and the opportunity to test actual Nitinol skate blades, how can the Examiner conclude that a person of only ordinary skill in the art would know, contrary to the opinions of experts, that a Nitinol knife blade would make a good skate blade. The Examiner is saying that the more ignorant worker in the art is better able to make the invention than the expert. Applicant does not believe that this proposition is supported by the case law.

Accordingly, Applicant believes that the claims in this application do define subject matter that is patentable over the prior art and respectfully requests that the Examiner pass this application to issue.

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Report on the novel Nitinol ice skate blade

Prepared by

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July, 2008

Executive summary

Several tests were executed in order to distinguish the advantages that the Nitinol skating blade could offer when compared to a regular skating blade. The tests comprised short and medium duration skating time trials at maximum skating speeds. The results show that the Nitinol blade offers a significant advantage for speed and quickness reaching a $p < 0.05$. Skaters using the Nitinol blade obtained faster time trials during the short and medium skating time trials when compared to the regular blade. Due to Nitinol's lighter weight, lower coefficient of friction, and sharper edge, skaters can achieve a greater number of strides which equates to faster speeds. In conclusion, the Nitinol blade shows an advantage of 2-5% in terms of skating speed, which is an important aspect in the game of hockey as the skater can reach the puck more quickly.

Goal

The goal was to test the effect of a new type of ice-skate blade material on skating performance. The material, named Nitinol, is a unique titanium alloy having the following novel characteristics:

- Lightness (14% lighter than steel used for hockey skate blades);
- Low coefficient of friction;
- Durability;
- Non corrosiveness;
- And flexibility.

Hypothesis

The hypothesis tested was that the weight advantage, the low coefficient of friction and the flexibility of this new material would improve skater agility/ability and overall performance.

Methods

Subjects

Tests for this pilot study were conducted on 4 ice hockey players. Homogeneity of the group was established by recruiting subjects of similar level of ice hockey skating agility. The level was set at the Canadian junior (major, AA and AAA) and college/university level. This was mandatory since the magnitude of change between skating with a regular blade and the new blade type risked not being very large (perhaps < 10%), but nonetheless sufficient to gain an advantage in hockey.

Experimental set up

The following physiological parameters were recorded on all 4 players: oxygen consumption (VO_2), carbon dioxide production (VCO_2), ventilation (VE) and energy expenditure (EE) with the use of a portable metabolic cart (K4b2, Cosmed, Italy). The heart rate (HR) was recorded with a specialised heart rate monitor belt (T31 Polar belt, Polar, Finland.) that allowed synchronising HR data with the portable metabolic cart and all other physiological parameters.

Lactic acid (La) systemic concentration was measured with a portable lactate analyser (Lactate Pro, USA) from a drop of arterialised blood obtained from the fingertip (index finger).

Skating speed and exact distance was determined by measuring displacements/movements on the ice sheet with a GPS at a 1 Hz resolution.

Finally, vibrations transmitted from the ice surface to the skate chassis was measured at different moments of the testing. The rationale was that vibrations may lead to the development of leg numbness that can cause an inhibition of the Hoffman reflex and loss of proprioception. Loss of proprioception typically leads to a decrease in skating efficiency due to the loss of perception of limb positioning in space. Thus, the hypothesis being tested was the potential for the Nitinol blade to attenuate vibrations during the overall skate stride. Briefly, a three axis accelerometer (ADXL 105, Analog Devices, Norwood, MA) was placed on the rear vertical blade mount. The root mean square (RMS) amplitude of the vibrations was calculated using commercially available software (Sigma Plot).

Experimental procedure

A total of 8 tests were administered to measure aptitudes of speed, endurance and agility. Fig 1 illustrates tests of speed and agility (Tests 1 to 7), while Test 8 (not shown) is designed to measure endurance and is described in details below. These 8 tests were executed with the players skating over two sessions with 48 hours of rest in between. A double blind randomisation was performed so that neither experimenter nor skaters knew which blades were being tested. Both the regular blades and the new blade type had the exact same sharpening.

- Prior to executing the tests, all players warmed up (free skating and stretching) for 10 minutes. All tests were carried out with complete hockey uniform. All tests were repeated twice and the better of two trials was retained for analysis.
  - ➢ Tests 1 to 5 were speed tests and were executed by skating as fast as possible. The independent variables measured for tests 1 to 5 were time of execution, heart rate and blood lactate concentration:
    - i) Test 1 (Fig. 1) involved skating forward and returning backward to the starting point as fast as possible. The test was repeated after a one minute rest period.

ii) Test 2 (Fig. 1) involved skating as quickly as possible over 9 meters 6 times executing stops and go at the end of each length. The test was repeated after a one minute rest period.

iii) Test 3 (Fig. 1) was similar to test 2 but rather than stopping at the end of each length the player executed a turn at the end of each length. The test was repeated after a one minute rest period.

iv) Test 4 (Fig. 1) involved forward skating with crossovers both while executing turns on the right and then on the left. The test was repeated after a 30 second rest period.

v) Test 5 (Fig. 1) was similar to test 4 but rather than forward skating the test was executed by backward skating.

- Test 6 consisted of measuring speed (time in seconds to the 100th precision) during a single all-out skate. The procedure consisted of having the subjects skate on the outer perimeter of the rink delimited by cones (within ~8 feet of the boards all around) at maximal skating velocity for three laps. This test was repeated following a 5 minute rest-period.
- Test 7 (Fig. 1) was an agility test that was performed with and without puck handling. At the starting point the player skated by slaloming through the cones (4.5 m between cones), circumvented the furthest cone and returned to the starting point as quickly as possible. The test was repeated after a one minute rest period.

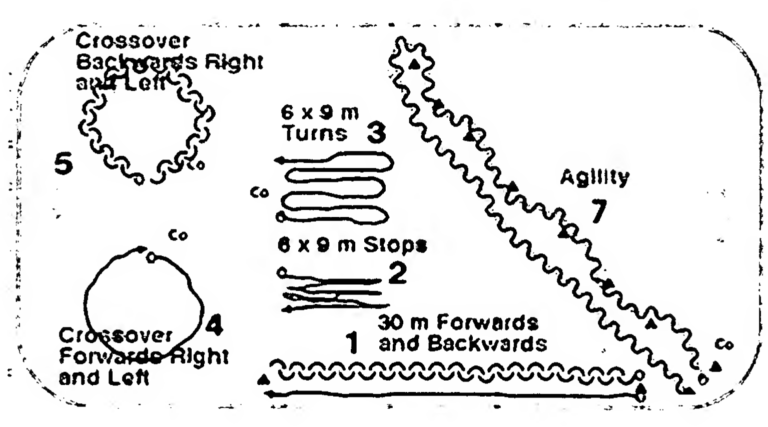

Fig. 1. Layout for speed and agility tests on the ice surface.

- Test 8 was an endurance test where EE was measured with the portable metabolic cart. The test measured the ability to sustain speed over a prolonged period of time. The test used was a progressive sub-maximal to maximal skating speed. Each skating stage was 1 minute duration separated by a 30 sec rest period until maximum skating speed was attained. The skaters followed auditory cues (beeps) that set the pace over a 50 m length stop and go skating course (roughly slightly beyond the center of the face off circles from one end to the other). The rationale was to reach steady state skating at each stage that allowed measuring oxygen consumption (VO_2), lactic acid production, and ventilatory requirements (VE). The hypothesis being that the new blade type would reduce metabolic requirements at submaximal speeds when compared to the standard blade. A reduction in metabolic requirements known as energy economy helps maintain one's reserve and offsets the time to fatigue development. As well, reducing the time of onset to fatigue could perhaps help reduce the risk of injury.

Data analysis

A descriptive analysis has been performed contrasting Nitinol blades to regular blades. Results are presented as mean ± S.D. Because of the small n (=4) no mean comparisons were performed to detect statistical significances, since some dependant variables did not share equal variances. When variances were uniform (Levene's test) a paired Student's t test was performed.

Results

Test 1

Physiological and time trial parameters recorded during **Test 1** (30 m forward and backward) are presented in Table 1.

Table 1. Physiological and time trial measurements during the 30 meters all out forward and backward skate (Test 1) (Values are mean ± SD)

Blade type	HR (bpm)	Borg Muscle	Borg Breathing	Time (s)
Nitinol	164±2.31	3.25±1.26	3.50±1.29	11.25±0.52
Regular	161±5.13	3.50±1.00	3.50±1.29	11.06±0.26

As shown in Table 1, there appears to be no significant differences between the parameters recorded while skating with either the Nitinol or regular blades.

Tests 2 to 5

Table 2 summarizes the physiological observations and time trials during **Tests 2 to 5**, which were all out speed and agility tests.

Table 2. Physiological and time trial measurements during Tests 2 to 5.

Blade type	HR (bpm)	[La] (mmol/L)	Borg Muscle	Borg Breathing	Time (s)
	Test 2. All out 9 meters x 6 stop and go				
Nitinol	172±4.36	10.45±1.33	4.75±0.96	4.38±1.49	12.08±0.21
Regular	167±5.72	9.30±1.33	3.88±1.18	4.38±1.89	12.14±0.45
	Test 3. All out 9 meters x 6 with turns (instead of stop and go)				
Nitinol	173±5.51	N/A	4.50±1.35	4.75±2.22	11.71±0.36
Regular	174±5.44	N/A	3.50±1.29	4.13±2.02	11.89±0.52
	Test 4. Skating forward with crossovers around face off circle (best of all)				
Nitinol	N/A	N/A	3.00±1.41	4.75±2.22	4.53±0.28
Regular	N/A	N/A	3.25±2.06	4.13±2.02	4.70±0.17
	Test 5. Skating backward with crossovers around face off circle (best of all)				
Nitinol	N/A	N/A	3.00±0.82	2.75±1.26	5.14±0.48
Regular	N/A	N/A	2.75±1.26	3.00±1.63	5.18±0.24

Values are mean ± SD; N/A, not applied.

As can be seen in Table 2, the Nitinol blade showed an increase in skating speed (Time column) since all of the time trials were shorter in duration when compared to the regular blade.

Test 6

The all out sustained maximum skating speed (per lap) is shown in Fig. 2 for both the Nitinol (filled circles) and Regular (empty circles) blades. As shown in Fig. 2, both time and speed were improved significantly ($p<0.05$) at the end of Lap 2 with the Nitinol blade when compared to the regular blade (Laps 1 and 3 not significant, $p>0.05$).

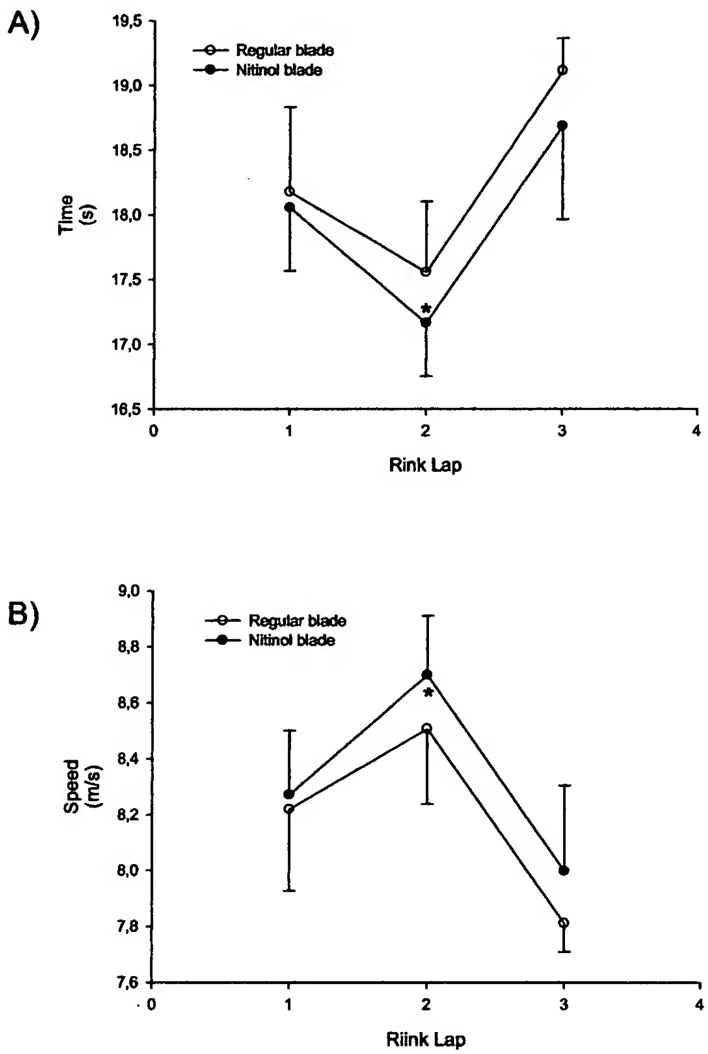

Figure 2. Sustained maximum skating speed 3 laps around the rink perimeter. A) Time trials; B) skating speed. Empty circles and filled circles represent regular blades and Nitinol blades, respectively. * Significantly different to the regular blade, $p<0.05$.

Table 3 presents absolute and relative differences in time and speed between the Nitinol and Regular blades during the 3 Laps around the rink perimeter at maximum speed (Test 6).

Table 3. Differences in time and speed between the Nitinol and Regular blades during Test 6.

	Δ t (s)	Δ t (%)	Δ speed (m/s)	Δ speed (%)
Lap 1	-0.12±0.50	-0.61±2.66	0.05±0.22	0.61±2.66
Lap 2	-0.39±0.20*	-2.22±1.09*	0.19±0.09*	2.22±1.09*
Lap 3	-0.43±0.52	-2.26±2.75	0.19±0.23	2.26±2.75

* Significant difference at $p<0.05$. Δ t, difference in time; Δ speed, difference in speed.

The differences in time and speed were statistically significant ($p<0.05$) at the end of Lap 2. As indicated, both the time and skating speed were improved significantly by 2.22±1.09 %.

On the other hand, **Borg scores** for both muscle and breathing sensations were similar between skating with either Nitinol or regular blades. Similarly, HR and blood lactate concentrations were not significantly different when skating with either Nitinol or regular blades (194±4.43 vs 193±4.58 bpm and 12.2±0.84 vs 11.5±1.77 mmol/L, respectively). The number of **skating strides** for the 3 laps was greater with the Nitinol blade when compared to the regular blade (134±14 vs 121±27 skating strides, respectively).

Test 7

Test 7, which is an agility test (skating with and without puck handling), revealed no significant differences in the time trials and physiological parameters while skating with either blade (Table 4).

Table 4. Physiological and time trial measurements obtained during Test 7 (skating with and without puck handling)

Blade Type	HR (bpm)		Borg Muscle		Borg Breathing		Time (s)	
	With Puck	Without Puck	With Puck	Without Puck	With Puck	Without Puck	With Puck	Without Puck
Nitinol	166±4.51	170±3.51	3.00±0.82	3.50±1.29	3.20±0.96	3.88±1.03	8.34±0.24	7.84±0.24
Regular	166±6.03	169±5.51	3.75±0.50	3.50±1.91	4.50±1.00	3.75±2.22	8.30±0.29	7.82±0.24

Values are mean ± SD

As well, both HR and Borg scores (muscle and breathing) showed no significant differences between skating with Nitinol or regular blades.

Test 8

Test 8 represents the progressive shuttle skating test to maximum skating speed. This test allowed measuring the oxygen consumption at sub-maximal to maximal skating speeds (VO_2max). Figure 3 shows the HR results that were recorded up to the last stage (stage 8) during the test. In general the HR values when skating with the Nitinol blade were slightly above the values obtained with the regular blades.

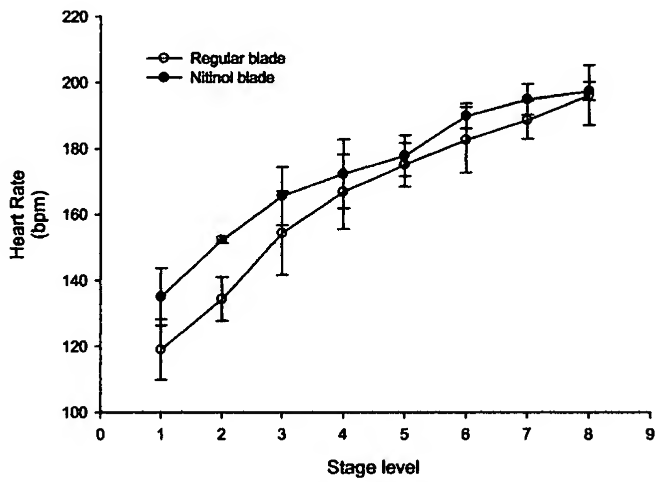

Figure 3. Sub-maximal and maximal heart rate (HR) recorded during the progressive shuttle skate test (Test 8). Empty circles and filled circles represent regular blades and Nitinol blades, respectively.

Borg scores (muscle and breathing, data not shown) and blood lactate concentrations ([La]) were similar at the end of the test regardless that the skater was using the Nitinol or regular blade ([La], 12.4±0.26 vs 11.9±0.80, respectively).

Vibrations

The preliminary analysis on vibrations does not reveal any distinctions in terms of central frequency spectrum between both blade types. This has to be confirmed or unconfirmed with further analysis.

We used time domain analysis of the vibration signals to measure the transition time from stopping to starting. It was very difficult to discern differences, however the Nitinol blade gave a slight advantage (confirmed by video analysis) to stop sooner with followed by more rapid start. As you can imagine, with the small number of players measured, the difference was small and within hundreds of a second. It was also observed by the experimenters (two observers) that the Nitinol blade cut deeper into the ice with the stop executed during Test 2 and the sharp turns executed during Test 3.

Discussion

The main finding with the novel skating blade Nitinol is related to skating speed and agility. Even though the total number of subjects was quite small (n = 4), the trend to be quicker while skating with the Nitinol blade is apparent, as observed particularly during the all out 3 laps (Test 6) around the rink perimeter (Fig 2 and Table 3). In fact, these differences amount to more than a 3 m (9 ft) and 0.5 m (1.5 ft) distance advantage over one lap or over 20 m (average distance for a hockey rink neutral zone), respectively. In other words, a skater using Nitinol blades would be ahead by either 3 m or 0.5 m. This brings a tremendous advantage to the game of hockey.

Oxygen consumption (Nitinol vs Regular blade skating)

The unexpected observation, however, was the greater heart rate and VO_2 measured during Test 8 at all sub-maximal levels while skating with the Nitinol blade in comparison to the regular blade (Fig 3). Nonetheless, the skating efficiency for stage 6 where the highest VO_2 values were obtained while skating with either blade, was similar (0.87±0.18 vs 0.93±0.14 VO_2/stride for Regular and Nitinol blades, respectively). One possible explanation is that even though the oxygen cost of skating was greater with the Nitinol blade the number of strides was also greater for every stage (data not shown) and resulted in similar skating efficiencies. In other words, the Nitinol blade allowed skaters to provide more strides when compared to the Regular blade. Perhaps one of the reasons for a greater number of strides with the Nitinol blade is that the blade is lighter (less lower limb momentum, thus quicker leg return) and harder, which improves the push aspect (better cutting/grip into the ice) during the power stroke.

As well, the maximum heart rate and VO_2 attained were similar regardless that the skater was using the Nitinol or regular blade. This suggests that all subjects reached their maximum physical capacity during both trials of testing with either the Nitinol or regular blade. This observation was also similar for blood lactate measurements during Test 8. Once again, indicating that the subjects reached their maximum.

Short distance skating

The trend to greater speed was also observed on short distances, as indicated in Table 2. The time differences are marginal but all tests point out in the same direction that a skater using the Nitinol blade is shown to be quicker. The Nitinol blade is also more flexible (claim by the

manufacturer) and this could also explain the greater energy cost (VO_2) while skating in a straight line (Test 8). The deformation of the blade during powerful strokes would absorb some of the energy transfer from skater to ice and thus require more energy (higher oxygen consumption) for attaining the same speed obtained with the regular blade. The flexibility, however, can be an advantage when turning (sharper turns) and in acceleration, this was observed during Test 2 and particularly during Test 3 (Table 2). As indicated, the time to complete the test 3 was quicker with the Nitinol blades vs regular blades (11.71±0.36 vs 11.89±0.52 s, respectively).

Psychometric evaluation of skating

Finally, using a psychometric questionnaire, 3 out of 4 players were able to identify correctly the blade on which they were skating. The results from the questionnaire showed clearly that the players gained a benefit from skating with the Nitinol blade.

Table 5. Psychometric data analysis

Blade type	Were able to identify the blade	Felt positive advantages	Would like to keep the blades
Nitinol	4.5±1	4.5±1	4.75±0.5
Regular	3.5±1.7	2.5±0.6	1.5±1.0

Values are mean ± SD. Answers were scored on a scale ranging between 1 and 5 (1 being "not sure" and 5 "sure").

Observations during game situation

Following testing, two (2) players used the blade during two week-end games. The day after we proceeded to a one-on-one 15-min interview to discuss their feelings while skating with the Nitinol blades during the games. Here are the comments (translated by the authors):

Player 1

I consider myself really fortunate to have the opportunity to try the Nitinol blades. I did different tests by myself during the weekend to compare my feeling between my old blades and this new product. It's hard to explain, but my feeling was definitively different particularly when I had to stop and to turn. I had the impression that the blade had a better grip on the ice and it was not because the blade was sharpened too

much. I didn't feel any blocking or any bouncing as we feel normally with the standard blade. In conclusion, I felt definitively and easily a difference and I can tell you that I loved it. I enjoyed tremendously the feeling to skate with these new blades.

Player 2

It's pretty easy to tell you, I liked the experience. I loved those new blades as I told you many times during the testing. I can confirm now as I tried them in competition. I felt that I was definitively faster and that my blades had a better grip. I felt advantages both in my turns and when I skated in a straight line. I felt like I had brand new legs (smile)!! It was a great experience to try the product. I want to thank you sincerely.

Head Coach comments

I can definitively tell you that I saw something special, something new with those two (2) players. They performed over my expectations during this weekend. They looked like they were faster and more aggressive. But it's hard for me to tell you if it's effectively 100% all about the new blades.

Conclusion

In conclusion, even though the total number of subjects is small ($n = 4$) test results show that the Nitinol blade offers an advantage at both short (Tests 2 to 5) and medium (Test 6) duration maximum skating speeds. The next logical step would be to validate these numbers with a larger cohort. Based on Cohen's analysis, a minimum of 22 subjects would be necessary to reach statistical significance ($\beta = 0.20$ at a < 0.05). As you were able to read, the player's comments on using the Nitinol blade are really positive.

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